

NOTES ON *BRANCHIOGLOSSUM* KYLIN (DELESSERIACEAE, RHODOPHYTA) IN THE EASTERN PACIFIC

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ABSTRACT. — Evidence is presented to demonstrate that *Branchioglossum bipinnatifidum* (Mont.) Wynne (hitherto known only from Chile), *B. woodii* (J. Ag.) Kyl. (hitherto thought to have a bipolar distribution, viz., Chile and Pacific North America), and *B. brattstroemii* Lev. (hitherto known only from Chile) represent a single species exhibiting a range of morphological variation in respect to thallus height and blade width. The correct name for this taxon and of the type for the genus is *B. bipinnatifidum*. *Branchioglossum undulatum* Daws., occurring from southern California to Baja California and the Gulf of California, is maintained as a separate species.

RÉSUMÉ. — Il est démontré que *Branchioglossum bipinnatifidum* (Mont.) Wynne (connu jusqu'ici seulement du Chili), *B. woodii* (J. Ag.) Kyl. (dont on pensait jusqu'ici que sa distribution était bipolaire, c'est-à-dire du Chili et du Pacifique de l'Amérique du Nord), et *B. brattstroemii* Lev. (connu jusqu'ici du Chili) ne constituent qu'une seule espèce présentant une série de variations morphologiques en ce qui concerne la longueur du thalle et la largeur de la lame. Le nom exacte de ce taxon et du type du genre est *B. bipinnatifidum*. *Branchioglossum undulatum* Daws., qui se rencontre du sud de la Californie à la Basse Californie et dans le Golfe de Californie, est maintenu comme une espèce distincte. (traduit par la rédaction).

KEY WORDS : *Branchioglossum*, *B. pinnatifidum*, *B. brattstroemii*, *B. undulatum*, *B. woodii*, Delesseriaceae, eastern Pacific, Rhodophyta.

INTRODUCTION

Branchioglossum, a genus of the red algal family Delesseriaceae, was described by Kylin (1924) and based on the type *B. woodii* (J. Ag.) Kyl., originally known from Vancouver Island, Canada. The genus is currently recognized to contain about 10 species (Ballantine & Wynne, 1987). The diagnostic characteristics of *Branchioglossum* include the following : flattened blades with apical organization of the Hypoglossum type (Kylin, 1924), that is, with all tertiary initials

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reaching the blade margin; blades essentially monostromatic, except for the midrib region; no lateral veins; branches developing from the blade margins, usually by the outgrowth of secondary initials by their transformation into primary (= indeterminate) initials (Wagner, 1954); and the production of tetrasporangia in two or more layers of the blade.

	Original description	Figures of holotype	Type locality
<i>B. bipinnatifidum</i> (Basionym: <i>Delesseria bipinnatifida</i>)	Montagne, 1837, p. 355 (Montagne, 1839/1847, pl. VI, fig. 1)	Fig. 1; Mikami, 1979, fig. II	Valparaiso, Chile
<i>B. woodii</i> (Basionym: <i>Delesseria woodii</i>)	J. Agardh, 1872, p. 54	Kylin, 1941, pl. 10, fig. 25	Vancouver Is., Canada
<i>B. macedougallii</i>	Gardner, 1927, p. 103	Gardner, 1927, pl. 20, fig. 4; pls. 33, 34	Libertad, Mexico
<i>B. undulatum</i>	Dawson, 1949, p. 17	Dawson, 1949, figs. 39-42	Santa Rosa, Is., California
<i>B. brattstroemii</i>	Levring, 1960, p. 65	Levring, 1960, fig. 6	Golfo de Ancud, Chile

Table 1. — Data on *Branchioglossum* spp. described from the eastern Pacific.

Five species occurring in the eastern Pacific (on the coasts of North and South America) have been assigned to *Branchioglossum* (Table 1). In a review of the literature it is evident that our knowledge of these species has often been based on a small number of specimens and has not taken into account possible morphological variation. It is also evident that confusion exists in regard to the relationship between species from North and South America.

The North American distribution of *Branchioglossum woodii* ranges from northern British Columbia, Canada, southward to Baja California and the Gulf of California, Mexico (Abbott & Hollenberg, 1976; Hawkes *et al.*, 1979). Gardner (1927) described *B. macedougallii* from Mexico, based on a single collection of a few sterile specimens. Dawson (1962) placed that species in the taxonomic synonymy of *B. woodii*, a judgement accepted by Abbott & Hollenberg (1976).

Dawson (1949) described *Branchioglossum undulatum* from Santa Rosa Is., California, and its distribution has been subsequently reported to include southern California, Baja California, and the Gulf of California (Dawson, 1962; Abbott & Hollenberg, 1976). This species has been distinguished from *B. woodii*

by its broad, undulate blades with obtuse apices and its rostrate cystocarps with strongly flared ostioles (Dawson, 1949).

Levring (1960) described *Branchioglossum brattstroemii* from the Golfo de Ancud, Chile, which had been collected by the Lund University Chile Expedition in 1948. Although the description was based on a single specimen, Levring was easily able to assign it to *Branchioglossum*, noting that the cells near the blade tips were «arranged in diagrammatic regularity». He also pointed out some resemblance to *B. woodii*. Santelices & Abbott (1978) reported the distribution of *B. brattstroemii* in Chile to range approximately from 30°S to 42°S. In a subsequent treatment Ramirez & Santelices (1981) made no reference to *B. brattstroemii* but stated that *B. woodii* has a bipolar distribution, occurring from British Columbia to Baja California in its northern hemisphere distribution and along the central coast of Chile in its southern hemisphere range.

In a careful examination of type material and recent collections of *Erythroglossum bipinnatifidum* (Mont.) Kyl., based on Montagne's (1837) *Delesseria bipinnatifida* from Valparaiso, Chile, Mikami (1979) observed that this alga conformed to the genus *Branchioglossum*. The transfer to *Branchioglossum* was subsequently made by Wynne (1983). Etcheverry (1986) has recently recognized both *Branchioglossum brattstroemii* and *Erythroglossum bipinnatifidum* in the Chilean flora.

The fact that *Branchioglossum woodii* has been depicted as having a bipolar distribution by Ramirez & Santelices (1981) raises questions: What is the relationship of *B. woodii* to *B. bipinnatifidum*? Are these two taxa possibly conspecific? The status of the other species involved, namely, *B. brattstroemii* and *B. undulatum*, also needs to be clarified. Collections of *Branchioglossum* made by the author from the Pacific coast of North America and made by Dr. R.B. Searles from the coast of Chile facilitated a reinvestigation of the genus and of the relationship between the populations occurring in these two geographically separated regions.

MATERIALS AND METHODS

The North American collections examined were preserved as herbarium specimens and/or preserved in 5 % formalin/sea water, whereas all of the Chilean specimens examined had been preserved in 5 % formalin/sea water. For microscopic study material was mounted in a mixture of 50 % liquid glucose (Karo Syrup) containing a few drops of 1 % aniline blue and acidified with a few drops of 1 N HCl. Photomicrographs were taken both with a camera-back mounted on a Zeiss research microscope or with a camera mounted on a Nikon SMZ-10 stereomicroscope.

The holotype of *Delesseria bipinnatifida* Mont. (in PC; Fig. 1) and specimens in TCD and LD (no. 31383 in Agardhian Herb.) were examined at these herbaria. The holotype of *Branchioglossum undulatum* Daws. was received on loan from AHFH, the Chilean material was received on loan from DUKE, and the

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remaining material used in this study is deposited in MICH. The symbols used for herbaria are taken from Holmgren *et al.* (1981).

The following North American specimens examined in this study are in MICH, and the Chilean specimens are in DUKE :

CANADA. British Columbia. Vancouver Island, Whiffin Spit, Sooke : 1.vii.1969, R. Norris 5893 (tetrasporic).

USA. Washington. San Juan County, San Juan Island, Lime Kiln Light : 18.vii.1978, Wynne 4919 (tetrasporic); 17.vii.1978, Wynne 4995 (*leg.* D. Perkins) (tetrasporic). California. Monterey County, Pacific Grove, Mussel Point : 29.vii.1941, G.M. Smith 41-419B (tetrasporic). Monterey Harbor : 21.vii.1965, I. Abbott 3772b (female, male).

MEXICO. Sonora. Ensenada de San Francisco : 12.vi.1952, Dawson 10996 (tetrasporic). Puerto Peñasco, Station Beach : 25.xii.1972, Wynne 3729; 27.xii.1972, Wynne 3769 (tetrasporic). Bahia Kino : 2.i.1973, Wynne 3870 (tetrasporic).

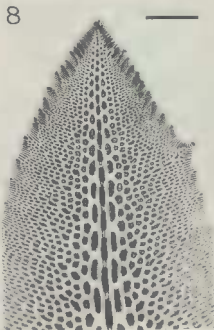
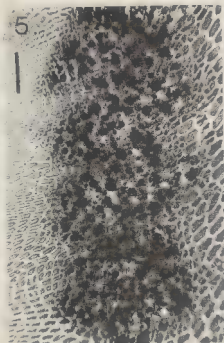
CHILE. SW of Isla May, near Puerto Alert ($49^{\circ}52.5'S$, $75^{\circ}14.4'W$) : 31.x.1972, Searles 72-21-21 (male). Puerto Albert ($49^{\circ}49.7'S$, $75^{\circ}16.5'W$) : 1.xi.1972, Searles 72-22-3 (male, tetrasporic). Isla Waller, Golfo de Peñas ($46^{\circ}48.3'S$, $75^{\circ}11.8'W$) : Searles 72-46-15. Isla Tres Dedos ($45^{\circ}18.9'S$, $74^{\circ}34.3'W$) : 12.xi.1972, Searles 72-50-26 (tetrasporic). Grupo Smith, Canal Darwin ($45^{\circ}25.5'S$, $74^{\circ}05.5'W$) : 16.xi.1972, Searles 72-59-41. Canal Drawin ($45^{\circ}24.5'S$, $74^{\circ}03.5'W$) : 24.v.1973, Searles 73-55-31 (tetrasporic). Small island E. of Isla Refugio ($43^{\circ}54.6'S$, $73^{\circ}06.6'W$) : 18.xi.1972, Searles 72-63-3. Canal Puquitrin ($43^{\circ}50.1'S$, $73^{\circ}47.0'W$) : 19.xi.1972, Searles 72-68-14 (male, female, tetrasporic); 20.xi.1972, Searles 72-70-23 (tetrasporic).

OBSERVATIONS

Examination of Lectotype of *Delesseria bipinnatifida* Mont.

Some of the confusion in regard to the interpretation of this taxon has become clarified by an examination of the lectotype and other specimens in the original d'Orbigny collection from Valparaiso. It turns out that this original collection contains a mixture of superficially similar entities, one *Branchioglossum* and the other *Erythroglossum*. The lectotype in PC (Fig. 1), so designated by Mikami (1979), indeed conforms to *Branchioglossum* in its apical organization, and I confirm Mikami's determination. In addition to the lecto-

Figs. 1-4 : *Branchioglossum bipinnatifidum*. Chilean collections. — Fig. 1. Holotype of *Delesseria bipinnatifida* in PC. Fig. 2. Blade apex. Fig. 3. Tetrasporic thallus. Fig. 4. Young tetrasporangia, Figs. 2 & 4, Searles 72-22-3; Fig. 3, Searles 72-68-14. Scale bars : 50 μ m in fig. 2; 1 mm in fig. 3; 100 μ m in fig. 4.



type specimen there is a second specimen on the same sheet with the same data, and it also is *Branchioglossum*. Also on this sheet is a packet containing some cards with specimens conforming to *Erythroglossum*; these are marked «*Delesseria bipinnatifida* Chile» but without the name of the collector. In TCD and LD there are d'Orbigny specimens conforming to *Erythroglossum*. It is understandable then why Kylin (1924, fig. 22e) depicted the apex of this taxon as conforming to *Erythroglossum*, since he based the figure on the specimen available to him in LD.

Examination of Chilean specimens

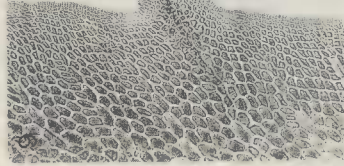
The Chilean specimens available in this study showed a wide range of thallus height, from 1 cm to about 10 cm, and a blade width of 1.5-4.0 mm. Branching was to 3 or 4 orders. Apical organization conforms to the Hypoglossum type, in which all tertiary initials reach the blade margin (Fig. 2). All cells of 2nd-order rows bear 3rd-order rows. Cells in the vicinity of the midline of the axis undergo periclinal and anticlinal divisions; these products of division then undergo elongation and contribute to the development of the midrib (Fig. 4).

Blade margins were at times entire but could appear moderately dentate on account of emergence of marginal branches. Branching in *Branchioglossum* is brought about by the conversion of a secondary initial into a primary initial, the new bladelet growing outward from the margin of the parent blade. Along a given blade margin there may be various stages in the production of new branches, with more advanced stages at times being distal to younger stages. This random sequence results in a dentate aspect.

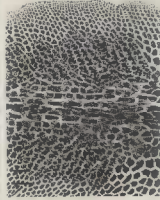
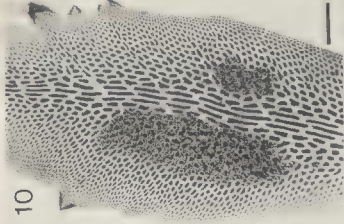
In one collection (Searles 72-68-14), all reproductive stages were present, with separate tetrasporic, male, and female thalli. Tetrasporic specimens bear sori on ultimate and penultimate branches (Fig. 3). Sori occur on both sides of the midrib and are arranged as continuous or interrupted zones, not encroaching on the midribs nor the blade margins. Sporangia are cut off from cortical cells, basically forming two layers of sporangia. Although the initial tetrasporangial arrangement appears orderly (Fig. 4), tetrasporangia are more irregularly arranged as the sorus matures (Fig. 5). Mature tetrasporangia ranged from 24-52 μm in diam.

Spermatangial sori were very similar to tetrasporangial ones in their arrangement in that they occurred on both ultimate and penultimate branches and produced both long, continuous or interrupted zones on both sides of the midrib (Fig. 6). Female plants likewise bore cystocarps on both ultimate and penul-

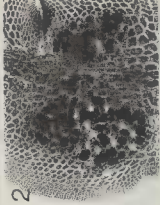
Fig. 5-8 : *Branchioglossum bipinnatifidum*. — Figs. 5-7, Chilean collections (Searles 72-68-14). Fig. 8, North American collection (Wynne 3769). Fig. 5. Sorus with mature tetrasporangia. Fig. 6. Male thallus. Fig. 7. Female thallus. Fig. 8. Blade apex. Scale bars : 100 μm in figs. 5 & 6; 500 μm in fig. 7; 50 μm in fig. 8.



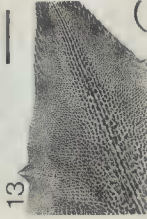
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imate branches (Fig. 7 & 14). Up to as many as three maturing cystocarps could be present along the midrib of a single blade.

Examination of North American specimens

The average height of the North American specimens observed was 2.5-3.0 cm. Blade width ranged from 1.5 to 3.0 mm, 2.0 mm being the typical blade width. Apices showed a Hypoglossum type of organization (Fig. 8). Blade margins were generally entire but could also be somewhat dentate because of the emergence of bladelets (Figs. 9 & 10). Blades were costate, the degree of cortication usually being pronounced but at times weakly expressed.

Almost all of the North American collections contained tetrasporic specimens. Tetrasporangial sori were located on both ultimate and penultimate branches and were present as a pair of broad, linear zones paralleling the midrib (Fig. 10). Sori may be arranged either in continuous or irregularly interrupted patches. Young sporangia appeared to be regularly arranged in the sori (Fig. 11), but this regularity was lost as the sporangia matured (Fig. 12). The mature, tetrahedrally divided tetrasporangia are 30-46 μm in diam. One female collection was observed. The thallus bore cystocarps on both ultimate and penultimate branches.

Examination of the Holotype of *Branchioglossum undulatum* Daws.

Present observations of the holotype of *B. undulatum* are in essential agreement with Dawson's (1949) account for this species. Blades have undulating margins and well developed midribs and are up to 5 mm broad. The blades terminate in obtuse apices. Otherwise, the apical organization is in general agreement with the other *Branchioglossum* collections examined, i. e., all tertiary initials reach the blade margin and all cells of 2nd-order rows bear thrid-order rows.

DISCUSSION

The alleged overlapping geographic distributions in Chile of *Branchioglossum woodii*, *B. bipinnatifidum*, and *B. battistroemii* stimulated this investigation of these related species. In J. Agardh's (1876) treatment of *Delesseria*, *D. bipinnati-*

Figs. 9-14 : *Branchioglossum bipinnatifidum*. Figs. 9-12, North American collections. Figs. 13 & 14, Chilean collections. Fig. 9, Emergence of marginal branch. Fig. 10. Tetrasporic thallus with marginal dentations. Fig. 11. Young tetrasporangia. Fig. 12. Mature tetrasporangia. Fig. 13. Emergence of marginal branch. Fig. 14. Young cystocarp located on midline of bladelet. Fig. 9, Abbott 3772b. Fig. 10, Wynne 3769. Figs. 11 & 12, Wynne 4995. Fig. 13 & 14, Searles 72-68-14. Scale bars : 70 μm in fig. 9; 100 μm in figs. 10-12; 200 μm in figs. 13 & 14.

fida and *D. woodii*¹ appeared alongside each other, and their descriptions started out identically: «fronde costata, lineari pinnatifide ramosa». Agardh referred to thalli of *D. woodii* as having entire margins with sori occupying the median portions of major segments and lying on opposite sides of the midrib, whereas he referred to thalli of *D. bipinnatifida* as having subdentate to serrate margins with sori in small marginal expanded bladelets. It is to be reiterated that the specimen of *D. bipinnatifida* in LD is an *Erythroglossum*, not a *Branchioglossum*.

It would also appear from the literature that the stature of thalli of *B. bipinnatifidum* is greater than that of *B. woodii*. These differences have up to now been based on relatively few observations, and so the availability of many collections from both Pacific North and South America has permitted a more thorough investigation of the taxonomic problems posed in the introduction.

Montagne's (1839/1847) original depiction of the habit of *Delesseria bipinnatifida* revealed a narrowly foliose alga, which was costate and with tripinnately divided blades (Fig. 1). He reported a height of about 15 cm. More recently Mikami (1979) reported Chilean specimens as being 13-18 cm tall and individual blades as 4-8 mm wide. Kylin (1941) stated that Californian specimens of *B. woodii* were more richly branched than the type specimen in the Agardhian Herbarium but that anatomically they were all in agreement. Smith (1944) gave a thallus height of up to 7 cm for specimens from Monterey, California.

As presented in the Observations, a considerable range in thallus height is apparent in the many South and North American collections examined in the present study. Although some of the Chilean specimens can be relatively robust, others are of much reduced height but otherwise are in morphological agreement. Thus, it is concluded that height cannot be used as a reliable means of distinguishing the North American from the South American specimens. Along similar lines, a comparison of the manner in which tetrasporangial sori are borne demonstrated that these sori are produced both on final-order bladelets and on the lower-order blades bearing these bladelets. This same feature was similarly true of the spermatangial and cystocarpic plants, which bore their reproductive structures on both ultimate and penultimate blades in both North and South American specimens.

The extensive morphological variation manifest in the many North and South American specimens examined has led me to conclude that thallus height, blade margin (entire vs. dentate), and location of tetrasporangial sori do not serve as sufficiently reliable criteria to distinguish *Branchioglossum bipinnatifidum* from *B. woodii*. The latter species is thus regarded as a taxonomic synonym of *B. bipinnatifidum*.

1. Subsequently Agardh (1898) transferred both species to his new genus *Erythroglossum* along with three other species, without designating a type. Although Kylin (1956) designated *E. bipinnatifidum* as lectotype of the genus, Wynne (1983) pointed out that Kylin (1924) had earlier designated *E. schousboei* (J. Ag.) J. Ag. as lectotype, and that lectotypification must be followed. Athanasiadis (1985) has more recently presented reasons for the conspecificity of *E. schousboei* and *E. sandrianum* (Kütz.) Kylin, the latter name having priority.

On the basis of a single specimen Levring (1960) described the thallus of *Branchioglossum brattstroemii* to have a height of 7 cm and a width of 5-7 mm, the lateral branches being 2-4 mm wide. Blades had acute apices, were costate, and bore linear tetrasporangial sori paralleling the midrib. Levring's characterization of the blade tips as having cells «arranged in diagrammatic regularity» is similar to Dawson's (1962) later description of *B. woodii* in which the «cells near branch tips were arranged with graphic regularity». It is not possible to distinguish *B. brattstroemii* from *B. pinnatifidum* (including *B. woodii*).

Finally, in regard to the remaining taxon, *Branchioglossum undulatum* Daws., the present examination of the holotype has confirmed Dawson's (1949) description of this alga as having blades with crisped or undulate margins and with broadly obtuse apices. Although it was not possible to visualize the rostrate nature of the pericarp over the cystocarps, owing to the pressed condition of the specimen, it seems reasonable to maintain *B. undulatum* as a distinct species, co-occurring with *B. bipinnatifidum* in southern California and Mexico.

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